NASA STTR 2005 Phase I Solicitation

T9.01 Rocket Propulsion Testing Systems

Lead Center: SSC

Proposals are sought for innovative technologies and technology concepts in the area of propulsion test operations. Proposals should support the reduction of overall propulsion test operations costs (recurring costs) and/or increase reliability and performance of propulsion ground test facilities and operations methodologies. As a minor element in a proposal for this topic, the offeror may include specific educational related research, technology advances, or other deliverables that address and support the Agency's education mission such as the enhancement of science, technology, engineering, and mathematics instruction with unique teaching tools and experiences. Specific areas of interest in this subtopic include the following:

Facility and Test Article Health-Monitoring Technologies

Innovative, nonintrusive sensors for measuring flow rate, temperature, pressure, rocket engine plume constituents, and effluent gas detection. Sensors must not physically intrude at all into the measurement space. Low-millisecond to sub-millisecond response time is required. Temperature sensors must be able to measure cryogenic temperatures of fluids (as low as 160R for LOX and 34R for LH_2) under high pressure (up to 15,000 psi), high flow rate conditions (2000 lb/s 82 ft/s for LOX; 500 lb/s 300 ft/s for LH_2). Flow rate sensors must have a range of up to 2000 lb/s (82 ft/sec) for LOX and 500 lb/sec (300 ft/s) for LH_2. Pressure sensors must have a range up to 15,000 psi. Rocket plume sensors must determine gas species, temperature, and velocity for H_2, O_2, hydrocarbons (kerosene), and hybrid fuels.

Rugged, high accuracy (0.2%), fast response, temperature measuring sensors and instrumentation for very high pressure, high flow rate cryogenic piping systems. Temperature sensors must be able to measure cryogenic temperatures of fluids (as low as 160R for LOX and 34R for LH_2) under high pressure (up to 15,000 psi), high flow rate conditions (2000 lb/s 82 ft/s for LOX; 500 lb/s 300 ft/s for LH_2). Response time must be on the order of a few milliseconds to sub-milliseconds.

Phenomenology, modeling, sensors, and instrumentation for prediction, characterization, and measurement of rocket engine combustion instability. Sensor systems should have bandwidth capabilities in excess of 100 kHz. Emphasis is on development of optical-based sensor systems that will be nonintrusive in the test article hardware or plume.

Improvement in Ground-Test Operation, Safety, Cost-effectiveness, and Reliability

Smart system components (control valves, regulators, and relief valves) that provide real-time, closed-loop control, component configuration, automated operation, and component health. Components must be able to operate in cryogenic temperatures (as low as 160R for LOX and 34R for LH_2) under high pressure (up to 15,000 psi) high flow rate conditions (2000 lb/s - 82 ft/s for LOX; 500 lb/sec - 300 ft/s for LH_2). Components must be able to operate in the elevated temperatures associated with a rocket engine testing environment. Response time must be on the order of a few milliseconds to sub-milliseconds.

Improved, long-life, liquid oxygen compatible seal technology. Materials and designs suitable for oxygen service at pressures up to 10,000 psi. Both cryogenic and elevated temperature candidate materials and designs are of interest. Typical temperature ranges will be either -320°F to 100°F, or -40°F to 300°F. Seal designs may include both dynamic and static use. Plastic, metal, or electrometric materials, or combinations thereof are of particular interest.

Miniature front-end electronics to support embedding of intelligent functions on sensors. Requirements include: computational power comparable to a 200 MHz PC with approximately 32 MB of RAM and similar non-volatile storage; analog input/output (I/O) (at least two of each with programmable amplification and anti-aliasing filters plus automatic calibration); digital I/O (at least eight) communication port for Ethernet bus protocol (one high speed and one low speed); support for C programming (or other high level language); and a development kit for a PC. The package should occupy a space no larger than 4" x 4" x 2". The system should include an embedded temperature sensor, an embedded stable voltage calibration source, and programmable switching to connect calibration source input and output.

New and innovative acoustic measurement techniques and sensors for use in a rocket plume environment. Current methods of predicting far-field and near-field acoustic levels produced by rocket engines rely on empirical models and require numerous physical measurements. New and innovative acoustic prediction methods are required which can accurately predict the acoustic levels a priori or using fewer measurements. New, innovative techniques based on energy density measurements rather than pressure measurements show promise as replacements for the older models.

Development of tools that integrate simple operator interfaces with detailed design and/or analysis software for modeling and enhancing the flow performance of flow system components such as valves, check valves, pressure regulators, flow meters, cavitating venturis, and propellant run tanks.

New and improved methods to accurately model the transient interaction between cryogenic fluid flow and immersed sensors that predict the dynamic load on the sensors, frequency spectrum, heat transfer, and effect on the flow field, are needed.

Modeling of atmospheric transmission attenuation effects on test spectroscopic measurements. Atmospheric transmission losses can be significant in certain wavelength regions for radiometric detectors located far from the rocket engine exhaust plume. Consequently, atmospheric losses can result in over-prediction of the incident radiant flux generated by the plume. Accurate atmospheric transmission modeling is needed for high-temperature rocket engine plume environments. The capabilities should address both the losses from ambient atmosphere and localized environments such as condensation clouds generated by cryogenic propellants.

Application of System Modeling to Ground Test Operations in a Resource Constrained Environment

New innovative approaches to incorporating knowledge and information processing techniques (prepositional logic, fuzzy logic, neural nets, etc.) to support test system decision making and operations. A requirement exists to develop, apply, and train intelligent agents, behavioral networks, and logic streams for rocket engine testing modes of operations and practice. Applications must operate statistically well on small and disparate data sources. The resulting products are inferential, representative, and they capture tacit and explicit knowledge. Statistical analysis must be supported.

Techniques to reduce required sample size to maintain acceptable levels of confidence in cost data. In order to use appropriate models and to manage the cost of data acquisition and maintenance, the minimization of required data sample sizes is critical.

Measurements and data are the product of ground testing. High accuracy, precision, uncertainty bands, and error bands are important elements of the data that is generated; this must be quantified. Techniques and models to determine these parameters for active test facilities are required.